EFFECTS ON THE SHRIMP PROCESSING INDUSTRY OF MEETING THE REQUIREMENTS OF WHOLESOME FISHERY PRODUCTS LEGISLATION

by

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Effects on the Shrimp Processing Industry of Meeting the Requirements of Wholesome Fishery Products Legislation

by

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ABSTRACT

Governments are increasingly taking responsibility to provide for the safety of consumers in the products they eat and use. In regulating production practices to insure this safety, there are almost always effects on producers in terms of added costs. There may also be added benefits to producers because the higher standards result in higher dollar sales either because more of the product is suitable for sale or a higher price is obtained for improved quality.

This paper analyzes Federal legislative proposals on fish inspection in the United States and how these might affect frozen shrimp processing plants. Costs are detailed for meeting minimum quality and sanitation standards likely to be enacted by the legislation. These are put in a time frame of 25 years, since some costs occur annually while investment costs occur only at

those times when an equipment item must be replaced.

The added sales value and the added costs are used to compute the net cash flow for each year of the analysis. This flow is discounted so that it is expressed in current market value. The rate of return on investment is then computed which shows the earnings which would occur from these expenditures. This analysis showed that if a firm, which was assumed for the analysis, could expect to save 2 percent of the total amount processed from spoilage, that the rate of return would be 30 percent. This would probably be high enough to attract most firms to install sanitary practices without mandatory inspection legislation. Many shrimp processors may have in fact already done so. Therefore, frozen shrimp processors probably will not be greatly affected economically by mandatory inspection. Nevertheless, the initial investment to install sanitary equipment and practices is quite large and consideration should be given by the Government to establish a loan fund to bring plants not now meeting acceptable standards up to minimum sanitation requirements.

INTRODUCTION

Quality standards for fish and shellfish products in the United States are receiving considerable public attention. Bills have been introduced before the U. S. Congress (1967, 1968, 1969) to require mandatory inspection of fish products. These specify minimum standards of sanitation and quality control in the handling and marketing of fish products. In considering this legislation, Congress has primary concern for the health and safety of the consumer of fish products. Nevertheless, in legislating changes in the acceptable practices of private firms, Congress would also like to know the effects of these changes on producers. One of the widely discussed inspection bills has a companion bill which would provide for loans to plants for meeting specific sanitation standards.[1] This paper outlines the conditions under which loans may be needed.

One segment of the industry--the Gulf and South Atlantic frozen shrimp processing plants--is selected for analysis. There is a higher frequency of contamination of breaded shrimp found by the U. S. Food and Drug Administration than for other fish products (U. S. Department of Health, Education, and Welfare, monthly), so this will be given special treatment.

The objective of the analysis is to determine the economic consequences of a minimum sanitation and quality standard on

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[1] S. 1092 and S. 1091, pending

frozen shrimp processing plants. These consequences will cover the obvious effect, that is cost, as well as the positive effect of added income to these plants. Benefits can come about from: (1) reduction in spoilage, thus enabling greater sales; (2) reduction in condemnation of contaminated products, again enabling greater sales; (3) reduction of "buy-backs" wherein the buyer refuses receipt of a product, due to its being below acceptable quality; and (4) an expansion of the market as consumers gain confidence in the product as one whose quality is acceptable on a continuous basis. The added costs and the added returns will be incorporated into an analysis which shows the net effect of minimum quality standards on the profitability of shrimp processing plants.

Most of the current inspection bills call for a study to be made of the fishing industry of one to three years' duration to determine the conditions in plants in order to specify good food manufacturing practices. This information is needed before a wholly reliable economic study can be made of the effects of standards. Information has been developed, however, which enables a preliminary analysis to be drawn between minimum quality standards and costs and returns to the plant.

CURRENT MANDATORY INSPECTION BILLS

Congressional bills for the mandatory inspection of fish products, although varying in several respects, are quite similar in terms of the sanitation and standards of wholesomeness required. Most call for a continuous inspection of all fish processing plants. More recent bills also provide for mandatory inspection of vessels, but not on a continuous basis.

Low quality or unwholesomeness in fish products is caused by bacterial contamination, chemical decomposition, and foreign matter (U. S. Department of the Interior, 1958 and Liston, 1965). Another type of unwholesomeness are additives to foods for purposes of preservation or enhanced appearance but which may be harmful to health. Both types are to be covered according to the proposed legislation. Our consideration of unwholesomeness is directed to contamination by the bacteria, yeasts, and molds which cause quality deterioration. The effects of bacterial forms which have more acute toxic effects when ingested such as Salmonella, Shigella, and Clostridium botilinum are a serious but somewhat different problem (Shewan, 1962). These are found much less frequently than food quality deterioration problems, although in many instances, control of food spoilage will also reduce the probable occurance of toxigenic organisms.

COMPARISONS WITH MEAT AND POULTRY ACTS

Fish is the only animal protein used for human food not now under strict inspection in the United States. Meat moving in interstate commerce has been subject to mandatory inspection since 1906 (U. S. Congress, 1906). The Act was greatly strengthened and expanded in 1967 (U. S. Congress, 1967). Poultry products come under compulsory inspection by an Act passed in 1957 (U. S. Congress, 1957). Both of these Acts call for strict inspection of plants and products and have provisions that imported products meet the same standards of processing required for domestically produced products.[2] Thus, the principal objective of fish inspection is to bring all animal protein foods under similar standards to the degree possible. Companion bills to some of the fish inspection proposals provide for subsidies to cover investment costs of bringing the plant up to minimum sanitary standards. These were not included in the meat or poultry inspection laws.

BACKGROUND OF THE SHRIMP INDUSTRY

Shrimp (*Penaeus* and *Pandalus spp.*) is by far the most valuable fish product in the U. S. at the landings level. The shrimp catch brought $103 million in 1967, while second ranked salmon (*Oncorhynchus spp.*) was sold for $49 million. At the processor level, shrimp

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[2] 81 Stat. 584, Title I, Sec. 6 and Sec. 20(a).
71 Stat. 441, Sec. 6(a) and Sec. 17(a).

products ranked second behind canned tuna (Euthynnus and Thunnus spp.) in total f.o.b. plant product value--$225 million compared with $270 million for canned tuna. The average value per pound was $1.03 (per kilogram was $0.47) for shrimp, and $0.685 (per kilogram was $0.31) for canned tuna.

Much of the sharp increase in shrimp marketed in the U. S. over the past 15 to 20 years has been supplied by imports. Domestic landings increased by 50 percent between 1958 and 1967, while imports increased 150 percent in the same period. Over half of the U. S. market is now supplied by imports. More than 70 countries shipped shrimp to the U. S. in 1967, although three countries, Mexico, India, and Panama shipped half of this volume. Mexico was the leader, exporting 70 million pounds (31,750 metric tons) in 1967.

About 80 percent of the U. S. supply of shrimp is sold to consumers as a frozen product. Three product forms account for the majority of shrimp sales: breaded, 50 percent; raw headless, 35 percent; and peeled and deveined, about 15 percent. The breaded, and peeled and deveined products are rapidly increasing in importance and are likely to continue to do so as the convenience food market expands. About one-third of the breaded shrimp

are processed from imported raw headless shrimp.

Shrimp processing plants are located throughout the Atlantic and Gulf regions where in 1967 about 80 percent of the domestic shrimp was landed and processed. Most plants produce two or more types of frozen shrimp, although there is notable specialization by area. Georgia, Florida, and Texas specialize in breaded shrimp. Louisiana, Mississippi, and Alabama concentrate on raw headless production, with Louisiana also being the major producer of canned shrimp.

CURRENT QUALITY PROBLEMS IN FROZEN BREADED SHRIMP PROCESSING

Breaded shrimp go through a number of stages in processing, each stage presenting opportunities for contamination. Other major processed forms differ only by going through fewer of these steps. The shrimp are received at the plant as raw headless, if obtained from local fishermen, while the imported product is received as frozen raw headless. After unloading, the shrimp is placed in cold storage until needed on the processing line. They are then thawed, if necessary, and washed. The next steps are to wash, size and grade, peel and devein and wash again. Breading follows, then they are packaged, weighed and wrapped. Finally, they are placed in the freezer, and after suitably frozen; placed in master cartons and moved to cold storage.

There are various means of performing each stage, although mechanization is increasing significantly in recent years. The most modern plants use conveyors to carry the product each step after the initial washing. In these plants, packing in the consumer boxes remains the most labor intensive part of the system. Both the machinery and the production line workers must be kept free of contaminants in order to produce an acceptable product.

To establish a relationship between food spoilage and cost of elimination or reduction of this spoilage requires that a causal chain be established. Bacteriological tests are commonly restricted to a few organisms such as Escherichia coli and coagulase-positive staphylococci. These are used as indicator organisms to point to the possibility of contamination by other food spoilage organisms and toxigenic bacteria, and by adulteration. These contaminants are generally not present in the live fish but are introduced during handling and processing. In discussing the possibility of the toxic organisms, Shigella and Salmonella, Shewan (1962) states, "Where conditions are suitable and contamination through a carrier or unsanitary handling does occur, then trouble can arise, and there are a sufficient number of well-documented incidents recorded in the literature to show that fish is no different in this respect from other foodstuffs . . . ."

There are accounts by the U. S. Food and Drug Administration that show the presence of indicator organisms in processed frozen shrimp with sufficient frequency to raise questions as to its freedom from contamination. An estimate of the total quantity of shrimp which contains these indicator organisms cannot be made. However FDA inspectors, who sample products in about one-third of the Nation's fish processing plants, have found violations in about one-third of the lots of shellfish sampled (U. S. Congress, Hearings, 1967). It is difficult to infer from this the total amount contaminated, since the actual amount inspected is a very small percentage and the objectives of the inspections do not include random sampling. The value of actual seizures of domestically produced frozen shrimp averaged about $100,000 (wholesale value) per year over the 5-year period 1962-67, or about 1 percent of total production. The reasons for seizures during a recent 2-year period are shown in table 1.

Indicator organisms as stated above have been shown to be a measure of various kinds of unwholesomeness in fish products. The next link is to determine the relationship between conditions in processing plants and the level of indicator organisms. Surkeiwicz, et al. (1968) surveyed 21 frozen shrimp processing plants with 1 to 5 lines per plant as a project for the U. S. Food and Drug Administration.

Table 1

Food and Drug Administration seizures for contamination of frozen shrimp products by reason, July 1966 - June 1968 (2 year total)

	Number of Shipments	Value of shipments	% value of total shipment value
Total shipments	66	$157,026	100.0%
		(with duplications)	
Charges:			
Escherichia coli		64,910	41.3
High bacterial count		112,936	71.9
Coagulase positive staphylococci		96,652	61.6
Excessive coliforms		74,649	47.5
Decomposed		24,326	15.5
Other		1,609	1.0

Source: List of Seizures, U. S. Department of Health, Education and Welfare, Consumer Protection and Environmental Health Service, Food and Drug Administration, Public Health Service

Some plants were surveyed twice, the second time being after the plant had changed operations to meet FDA recommendations. The report shows a striking contrast between the level of indicator organisms for those plants using "good" sanitary practices and those using "bad" sanitary practices.

A principal value of the report for analytical uses is that the "good" and "bad" are specified by relating the plant conditions, equipment, and practices to levels of contamination. Complementing this study, Clem and Garrett (1968) report the equipment, materials specifications and practices to be used in shrimp processing for a sanitary operation. The analysis being reported here attaches dollar costs to the equipment and practices specified by Clem and Garrett, and determines the effects of these on the profitability of the plant.

Precise quality standards will not be established until legislation is enacted. Therefore, this analysis must assume a set of standards. The two studies cited above outline a set of sanitation guidelines which are generally acceptable to keep contamination at or below acceptable levels. These guidelines are used in this report.

COSTS OF QUALITY CONTROL

Changing a plant to improve product quality affects nearly every facet of the building, equipment, and operating practices.

In order to analyze the cost effects, each of the changes must be specified. It is often difficult to determine if a specific item should be changed strictly from the standpoint of quality improvement. Many items can be installed which improve product quality, but the real justification for installation may be to improve economic efficiency. Those costs incurred for the latter reason should not be counted as a cost of changing to mandatory inspection. There may also be a tendency for government officials and others who are concerned with food quality to specify changes which more than meet minimum standards. This study includes, insofar as is known at this time, only the standards needed to meet the requirements likely to be enacted and analyzes plant changes necessary to meet these standards.

Table 2 shows in summary form the specifications for meeting minimum quality standards in breaded shrimp production.[3] The standards as shown in the left column involve (1) personal cleanliness, (2) cleanliness of facilities and equipment, (3) shrimp handling practices, and (4) standards for the physical plant (buildings, plumbing, etc.). To achieve each of these standards requires several kinds of costs as shown in the column headings; these being (1) facilities, (2) building, (3) supervisory and production labor, and (4) materials. For example, the first item, personal cleanliness, requires costs of facilities (basins, towels, and soap despensers), building installations (ventilation), both

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[3] Based on Clem and Garrett, 1968.

Table 2

Classification of quality control co[illegible]

Specification for minimum standard	Type of Cost: Facilities	Building	Supervisory and production labor	Materials
A. Personal				
Wash hands after using toilet	Wash basin and dispensers	Ventilation	Rule enforcement[1/] employee time[2/]	Soap, disposable towels, hot water
Sanitize hands before entering production area and when changing jobs	Sanitizing station at entrance to processing areas		Rule enforcement[1/] employee time[2/]	Water and sanitizing solution 50 ppm available chlorine
Special clothing				Hair covered, clothing over, or in place of street clothes
B. Clean utensils and equipment, building				
Design	Pans, trays, racks, tanks, tables, breader: smooth surfaces and rounded corners of impervious materials		Supervisor, inspection and purchasing[1/]	
Sanitize utensils, equipment	Automatic chlorination system		Rule enforcement[1/] perform 2 times per day[2/] flush, then scrub, rinse with	Potable water and sanitizing solution 50 ppm 170° F. (76.67° C.) water

Table 2 (continued)

Classification of quality control costs

Specification for minimum standards	Type of Cost: Facilities	Building	Supervisory and production labor	Materials
B. Clean utensils and equipment, cont.				
Breading machine	Automatic chlorination system		Rule enforcement[1] perform 2 times per day[2], flush, then scrub, rinse with chlorinated water[2]	Potable water and sanitizing solution 200 ppm 170° F. (76.67° C.) water
Liquid batter: low bacteria count	Batter chill unit[3]		Keep iced, discard[1,2,3] every two hours	Increased ice,[3] increased batter
Conveyance	Carts, pallets or belts		Saving of labor[2]	
Floors			Clean once per day[2]	200 ppm 170° F. (76.67° C.) water
C. Handling of Shrimp				
Holding of shrimp Thaw in cold running water or tanks	Tanks or spray nozzles		rule enforcement[1] labor[2]	Potable water ice
Minimize time shrimp on processing line	Technically efficient processing line, placement of workers, etc.		Supervisory time[1] labor saving[2]	ice
Place shrimp in freezer soon after packing	May require space adjustments		Supervisory[1] labor[2]	

Table 2 (continued)

Classification of quality control costs

Specification for minimum standard	Type of Cost: Facilities	Building	Supervisory and production labor	Materials
C. Handling of Shrimp, cont.				
Wash shrimp before and after peeling-deveining	Tanks or spray nozzles		Rule enforcement[1] labor[2]	Potable water
D. Building				
Floors, walls		Hard, impervious free of cracks, all surfaces of construction to permit thorough cleaning floors sloping to rodent-proof drain		
Plumbing		Water sufficient pressure approved source		
Waste disposal		Discharge in public sewers or inaccessible to rodents and insects		
Screens		Doors, self-closing windows	Supervisory[1]	

Table 2 (continued)

Classification of quality control costs

Specification for minimum standard	Type of Cost: Facilities	Building	Supervisory and production labor	Materials
D. Building, cont.				
Large doors		Fly fans		
Dry storage area		Does not receive floor drainage from processing area		

1/ Supervisory time

2/ Production worker time

3/ A plant may use a batter chill unit or keep the batter sufficiently iced by hand.

supervisory (rule enforcement) and employee time (washing hands), and materials (soap, towels, and water).

The items of cost apply to any shrimp breading operation, regardless of plant size, location and any other specifics of the operation. In order to establish the effects on profitability, however, it is necessary to specify the type of plant under analysis. One of the major specifications is in the size of the plant. Shrimp breading plants in the South Atlantic and Gulf vary in output from less than a million pounds (less than 100 metric tons) annually to over 10 million pounds (4,500 metric tons). There is no average or typical plant. Most plants handle breaded shrimp along with other products, but again, there is none which could be considered typical.

The plant chosen for the remainder of the analysis is an assumed one which produces 2 million pounds (907 metric tons) of breaded shrimp annually, and 1 million pounds (454 metric tons) of other frozen packaged shrimp products such as peeled and deveined and raw headless. Costs and returns are shown in terms of those which existed during the 1967-68 period. For quick reference, the average value of frozen shrimp at the plant in recent years has been approximately 1 dollar per pound ($0.45 per kilogram), so dollar and pound volume are roughly equal.

Tables 3 and 4 show the dollar costs of quality control for

Table 3

Annual plant operating costs of quality control processing--3 million pounds per year

Item	Unit	Quantity	Cost per unit (dollars)	Total cost (dollars)
Materials Costs				
Workers' cleanliness				
soap, paper towels, hot water, sanitizing solution, etc.	worker	70	30	2,100
special clothing	set	150	10	1,500
Hot water for cleaning	1,000 gal. (kl.)	1,000 (3,784)	.70 (.18)	700
Sanitizing solution for cleaning equip.				500
Change breading material	lbs. (kg.)	50,000 (22,680)	.11 (.24)	5,500
Prepare and maintain shrimp				
Thaw, wash, cool				
ice	lbs. (kg.)	1,000,000 (453,597)	.015 (.033)	15,000
water	1,000 gal. (kl.)	2,000 (7,568)	.70 (.18)	1,400
Utilities	$/lb. (kg.)	3,000,000 (1,360,791)	.0001 (.00022)	300
Labor Costs				
Wash hands	man-hr.	2,900	1.70	4,930
Utensil cleaning	man-hr.	3,000	1.70	5,100
Exchange batter in breading machine	man-hr.	300	1.70	510
Clean floor, building	man-hr.	400	1.70	680
Thaw shrimp	man-hr.	0 net	1.70	0
Wash shrimp	man-hr.	0 net	1.70	0
Labor saving from modern peeler-deveiner	man-hr.	3,000	1.70	-5,100
Product inspection (added)	man-hr.	2,000	3.50	7,000
Supervisory Costs				
Rule enforcement (personal and plant cleanliness and inspection of premises)	man-hr.	1,000	5.00	5,000
Total annual operating costs				45,120

Table 4

Plant investment costs of quality control - frozen shrimp processing--3 million pounds per year

Item	Unit	Quantity	Cost per unit (dollars)	Useful life (years)	Total cost (dollars)
Utensils and equipment					
Hand washing stations	no.	10	15	10	150
Washing vats	no.	3	80	10	240
Peeling-deveining machines	no.	12	5,000	10	60,000
Conveyor tables	no.	1	1,650	10	1,650
Batter chill unit	no.	1	3,800	10	3,800
Packing tables	no.	1	1,800	10	1,800
Hi-pressure cleaner	no.	1	500	10	500
Pans	no.	50	2.00	5	100
Trays	no.	125	2.30	10	288
Automatic chlorination system	no.	1	3,200	10	3,200
Hot water system	500 gal. (1892 kl.)	1	400	10	400
Floor arrangement improve space utilization for rapid handling and placement in freezer					
Building					
Floors and walls (see table 2)	sq. ft. (929 cm^2)	10,000	2.00	15	20,000
Plumbing and waste disposal (see table 2)				15	10,000
Screen doors and windows (see table 2)				5	300
Fly fans at utility doors (see table 2)				10	100

a plant of the above size and output. The items are taken from table 2 and rearranged to more easily present the cost statement. It should be emphasized that these are not the total costs of shrimp processing, but only show the added costs which would be incurred by meeting minimum quality standards. These costs are for a situation where none of the items are installed or cleanliness practices are now followed. In this same plant where some of these are now incorporated, the costs of meeting minimum standards would be correspondingly lower.

Table 3 shows the additional operating costs which would be incurred each year. Table 4 shows investment items. The second column from the right indicates the life of each piece of equipment, thus inferring the frequency of purchase necessary. These figures of necessity are a composite of recent costs which generally represent those existing in Gulf and South Atlantic shrimp plants.

To the authors' knowledge, there has not been a study of processing plants which would more precisely determine some of the physical costs. The most uncertain figures are those of employee time required. The manufacturing studies which are proposed in the mandatory inspection bills presumably will derive much better data on these, as well as the other costs.

The biggest single cost item is the modern peeler-deveiner

which costs about $5,000 per unit and handles sixty shrimp per minute. Several models are available which vary around this price and performance. There is some uncertainty whether this peeler-deveiner is essential to meet quality standards. It is a faster machine than those available a few years ago which means the shrimp are out of the freezer for a shorter time, resulting in a lower bacterial count. However, the principal reason for installing it could well be for reasons of economic efficiency. An annual savings of $5,100 in labor is obtained from use of this machine. Given this uncertainty as to need, the cost and return analysis which follows was done both ways--with and without the modern peeler-deveiner.

NET CASH FLOW-INTERNAL RATE OF RETURN

The cost analysis is only one phase of the analysis of the economic effect of mandatory inspection. The next step is to consider increase in sales possible from producing a higher quality product. As stated above, the sales losses due to poor quality are largely unknown. FDA reports the seizures, but the data are inadequate to extrapolate to total quality losses. In a survey of shrimp processors by the authors in April 1969, plant operators stated that losses were very low or nonexistent.

Since data are insufficient to make reliable estimates of

percent of value lost due to low quality, various assumptions on these losses were made. These were (1) 1 percent, (2) 2 percent, and (3) 3 percent loss on the total 3 million pounds of output, and (4) 3 percent on the breaded shrimp with no losses on the other products. As can be seen later, these levels vary from a net cost to the plant, to cases in which quality improvement is highly profitable. Each level was done on the assumption of the necessity of purchasing a peeler-deveiner as stated above, and alternatively, on the assumption of a peeler-deveiner not being needed.

The added cost figures and the added revenue flowing from increased sales were incorporated into what is known as a net cash flow model as shown in tables 5 and 6. This model is somewhat different from many investment analyses used, although it has been developed for decades (Keynes, 1965). One of the basic concepts is the net cash flow. This is simply the net of the receipts and expenditures during a year. Expenditures include both the operating and investment costs. This is a very straightforward accounting of the volume of the net cash flow each year showing whether receipts are greater than expenditures for the project analysed. The four columns on the right of each table show net cash flow under stated conditions.

The next basic concept in using these data is discounting,

Table 5

Net cash flow of quality control costs
Assumption: peeler-deveiner is necessary

Year	Annual costs	Costs occurring every 5 years	Costs occurring every 10 years	Costs occurring every 15 years	Total cost in the year	Net cash flow for percentage loss reduction: 1 percent on all shrimp 1/	2 percent on all shrimp 1/	3 percent on all shrimp 1/	3 percent on breaded shrimp only 1/
0	45,620	400	72,128	30,000	148,148	-112,748	-77,348	-41,948	-91,148
1	45,120				45,120	-9,720	25,680	61,080	11,880
2	45,120				45,120	-9,720	25,680	61,080	11,880
3	45,120				45,120	-9,720	25,680	61,080	11,880
4	45,120				45,120	-9,720	25,680	61,080	11,880
5	45,120	400			45,520	-10,120	25,280	60,680	11,480
6	45,120				45,120	-9,720	25,680	61,080	11,880
7	45,120				45,120	-9,720	25,680	61,080	11,880
8	45,120				45,120	-9,720	25,680	61,080	11,880
9	45,120				45,120	-9,720	25,680	61,080	11,880
10	45,120	400	72,128		117,648	-82,248	-46,848	-11,448	-60,648
11	45,120				45,120	-9,720	25,680	61,080	11,880
12	45,120				45,120	-9,720	25,680	61,080	11,880
13	45,120				45,120	-9,720	25,680	61,080	11,880
14	45,120				45,120	-9,720	25,680	61,080	11,880
15	45,120	400		30,000	75,520	-40,120	-4,720	30,680	-18,520
16	45,120				45,120	-9,720	25,680	61,080	11,880
17	45,120				45,120	-9,720	25,680	61,080	11,880
18	45,120				45,120	-9,720	25,680	61,080	11,880
19	45,120				45,120	-9,720	25,680	61,080	11,880
20	45,120	400	72,128		117,648	-82,248	-46,848	-11,448	-60,648

Table 5 (cont.)

Net cash flow of quality control costs
Assumption: peeler-deveiner is necessary

Year	Annual costs	Costs occurring every 5 years	10 years	15 years	Total cost in the year	Net cash flow for percentage loss reduction: 1 percent on all shrimp 1/	2 percent on all shrimp 1/	3 percent on all shrimp 1/	3 percent on breaded shrimp only 1/
21	45,120				45,120	-9,720	25,680	61,080	11,880
22	45,120				45,120	-9,720	25,680	61,080	11,880
23	45,120				45,120	-9,720	25,680	61,080	11,880
24	45,120				45,120	-9,720	25,680	61,080	11,880
25	45,120	400			45,520	-10,120	25,280	60,680	11,480

1/ The difference between total cost and total receipts due to loss reduction. The value of loss reduction is computed by the percent loss reduction multiplied by a price of $0.95 per pound ($0.43 per kilogram) for breaded shrimp and $1.65 per pound ($0.75 per kilogram) for other processed frozen shrimp.

Table 6

Net cash flow of quality control costs
Assumption: [illegible] inor is [illegible]

Year	Annual costs	Costs occurring every 5 years	10 years	15 years	Total cost in the year	Net cash flow for percentage loss reduction: 1 percent on all shrimp 1/	2 percent on all shrimp 1/	3 percent on all shrimp 1/	3 percent on breaded shrimp only 1/
0	50,720	400	12,128	30,000	93,248	-57,848	-22,448	12,952	-36,248
1	50,220				50,220	-14,820	20,580	55,980	6,780
2	50,220				50,220	-14,820	20,580	55,980	6,780
3	50,220				50,220	-14,820	20,580	55,980	6,780
4	50,220				50,220	-14,820	20,580	55,980	6,780
5	50,220	400			50,620	-15,220	20,180	55,580	6,380
6	50,220				50,220	-14,820	20,580	55,980	6,780
7	50,220				50,220	-14,820	20,580	55,980	6,780
8	50,220				50,220	-14,820	20,580	55,980	6,780
9	50,220				50,220	-14,820	20,580	55,980	6,780
10	50,220	400	12,128		62,748	-27,348	8,052	43,452	-5,748
11	50,220				50,220	-14,820	20,580	55,980	6,780
12	50,220				50,220	-14,820	20,580	55,980	6,780
13	50,220				50,220	-14,820	20,580	55,980	6,780
14	50,220				50,220	-14,820	20,580	55,980	6,780
15	50,220	400		30,000	80,620	-45,220	- 9,820	25,580	-23,620
16	50,220				50,220	-14,820	20,580	55,980	6,780
17	50,220				50,220	-14,820	20,580	55,980	6,780
18	50,220				50,220	-14,820	20,580	55,980	6,780
19	50,220				50,220	-14,820	20,580	55,980	6,780
20	50,220	400	12,128		62,748	-27,348	8,052	43,452	-5,748

Table 6 (cont.)

Net cash flow of quality control costs
Assumption: peeler-deveiner is not necessary

Year	Annual costs	Costs occurring every 5 years	10 years	15 years	Total cost in the year	Net cash flow for percentage loss reduction: 1 percent on all shrimp 1/	2 percent on all shrimp 1/	3 percent on all shrimp 1/	3 percent on breaded shrimp only 1/
21	50,220				50,220	-14,820	20,580	55,980	6,780
22	50,220				50,220	-14,820	20,580	55,980	6,780
23	50,220				50,220	-14,820	20,580	55,980	6,780
24	50,220				50,220	-14,820	20,580	55,980	6,780
25	50,220	400			50,620	-15,220	20,180	55,580	6,380

1/ The difference between total cost and total receipts due to loss reduction. The value of loss reduction is computed by the percent loss reduction multiplied by a price of $0.95 per pound ($0.43 per kilogram) for breaded shrimp and $1.65 per pound ($0.75 per kilogram) for other processed frozen shrimp.

which determines the current market value of the quality improvement project. In the case of 1 percent loss reduction, this discounted value or net cash flow is negative, that is, shows a net cost to the plant, while for greater savings it is positive, which shows added receipts exceeding added costs. Table 7 shows these values for each of the conditions analyzed. The figures are for a discount rate of 25 percent. A high rate is used because these are modifications of an existing plant, and without an analysis of the profitability of the entire operation. Thus, when firms make partial changes such as this, a high rate of return is usually required to undertake the change voluntarily.

Table 7

Discounted net profit (cost) in dollars of meeting minimum quality standards

	With peeler-deveiner	Without peeler-deveiner
Loss reduction		
1% on all shrimp	(161,307)	(119,596)
2% on all shrimp	15,158	56,869
3% on all shrimp	191,426	307,598
3% on breaded shrimp only	(53,634)	(11,922)

To give a better reference to those figures, table 8 shows the net profit (cost) per thousand pounds of shrimp processed over the 25-year period which the analysis covers.

Table 8

Discounted profit (cost) in dollars per 1,000 pounds of shrimp of meeting minimum quality standards

	With peeler-deveiner	Without peeler-deveiner
Loss reduction		
1% on all shrimp	(2.15)	(1.59)
2% on all shrimp	.20	.76
3% on all shrimp	2.55	4.10
3% on breaded shrimp only	(.72)	(.15)

A much better measure of the economic effects of mandatory inspection is the rate of return on expenditures which must be made. The method chosen to obtain this measure is the net cash flow-internal rate of return. The internal rate of return is defined as "the interest rate that equates the present value of expected future receipts to the present value of the investment outlay." (Weston and Brigham, 1966) It is the rate of compound interest at which the present value of the total expenditures on a project would have to be invested at the current time to yield the earnings of the project investment. The

internal rate of return under the conditions of this analysis are given in table 9.

Table 9

Internal rate of return of meeting minimum quality standards

	With peeler-deveiner	Without peeler-deveiner
Loss reduction		
1% on all shrimp	*	*
2% on all shrimp	30	91
3% on all shrimp	145	376
3% on breaded shrimp only	3	14

* Internal rate of return cannot be computed because it is negative

Tables 7, 8, and 9 show the extreme sensitivity of profits (or costs) of changing manufacturing practices to various levels of quality savings. If only 1 percent can be saved by these added costs, the plant will have added net costs. A 2 percent savings of loss on all shrimp will be highly profitable to the plant, even with the purchase of a peeler-deveiner, although obtaining the machine has a phenomenal effect on the internal rate of return.

If the savings can be made only on breaded shrimp, this

would not be voluntarily undertaken at a 3 percent savings where the peeler-deveiner is needed, but would be more attractive if the machine is not needed, in which case the return is 14 percent.

Hand breading is done by some plants in the Gulf and South Atlantic. The reason for continuing this labor intensive practice is to produce a product which has a high demand and thus receives a higher price than the machine breaded shrimp. Available data indicate hand breaded shrimp commands 20 to 25 percent higher price.

The costs incurred to meet minimum sanitation standards differ somewhat from the cases analyzed. The additional contact with workers increases the need for strict cleanliness rules. Batter and breading must be changed more frequently. On the other hand, the time which was allocated to cleaning the breading machine is saved. All items considered, the net change in costs attributed to sanitation requirements is quite small.

The major change from the foregoing analysis would be that for a given percentage spoilage reduction, a higher dollar return is received from hand breaded shrimp. Therefore, more of a profit incentive exists for reducing spoilage of the hand breaded product.

CONCLUSIONS

Based on the internal rates of return shown in table 9, the profit motive has probably led the shrimp processors to install

much of the equipment and practices which mandatory inspection would require. These results lend credence to the report by shrimp processors that they now experience very little spoilage losses. It is necessary to reduce losses by more than 1 percent in the case analyzed to make it an economically attractive change. A 2 percent loss reduction is quite profitable. Quite possibly the costs stated here are higher than those which would be incurred by many firms, since they have already incorporated several of these changes into their operation.

A change in the price of shrimp can have an important effect on whether installation of sanitary practices is profitable. A higher valued product makes it more important to reduce losses. By the same token, lower valued products with the same loss reduction would not yield a rate of return as high as for shrimp. The profit motive would not be as powerful in attracting firms to reduce quality losses, as a given percentage loss would not result in the same dollar loss. As prices increase, the motivation to improve quality also increases.

There has been considerable debate since the beginning of mandatory inspection proposals as to the effects on profits of private enterprise. A good deal can be learned from this analysis as to the conditions under which this would be detrimental to firms.

More important, this sets one framework under which the effects on given groups of processors can be studied. It shows the necessity of integrating bacteriological relationships, knowledge of food processing practices, and economic analysis to obtain requisite information for policy conclusions.

Although firms may find that installation of a system to meet sanitation requirements is quite profitable over a period of time, the initial investment required could be a severe handicap for many firms. If the peeler-deveiners are installed, the initial cost is nearly $150,000 (table 6) or without this, the cost is over $90,000 (table 7) for the size of plant considered. Initial investments of this magnitude to meet a change in Government regulations would indicate that serious consideration should be given to establishing a loan fund.

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